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COMPARISONS OF METEOROLOGY FROM A WEATHER-CHEMISTRY FORECAST MODEL WITH OBSERVATIONS DURING THE TEXAQS-2000 FIELD STUDY

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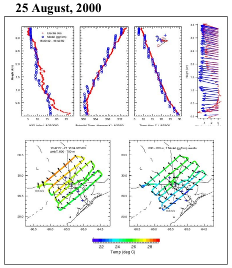
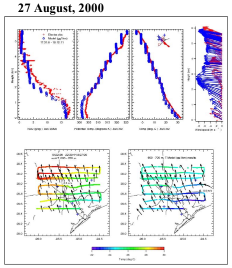
Motivation: To utilize the observations from the TEXAQS-2000 field experiment in the evaluation of the performance of NOAA's coupled weather-chemistry model for the purpose of improving operational quantitative air-quality forecasts. Over the past two years, the NOAA model has been used in experimental regional real-time air-quality forecasts.

Model Forecasts and Aircraft Data Comparison

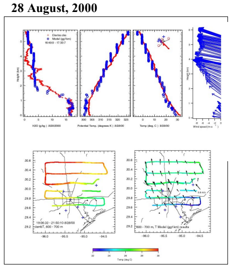
25 August, 2000



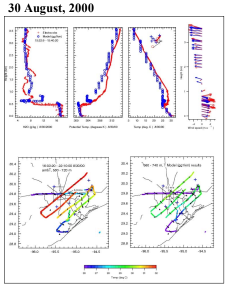
27 August, 2000



28 August, 2000



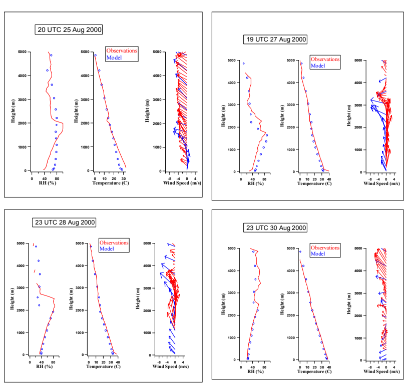
30 August, 2000



Comparison of model forecasted (from the 1.67 km grid) winds, temperature and moisture with aircraft data on 25, 27, and 30 August 2000:

- Model forecasts possess a cold bias at low levels.
- The PBL temperature is colder than that observed when the prevailing low level winds are from the Gulf of Mexico.
- When the low-level winds are from inland, the PBL temperature is in better agreement with observations.
- A cold bias in the marine boundary layer is suggested.

Model Forecasts and Sounding Data Comparison



Comparison of model forecasted (from the 1.67 km grid) winds, temperature and relative humidity with rawinsonde data taken at 29.95° N, 95.54° W on 25, 27, 28, and 30 August 2000:

- Biases revealed by the comparison with aircraft data are confirmed.

Selected cases: high surface ozone episodes during the time period of 25-30 August 2000.

Quantitative comparison using aircraft and rawinsonde data: to reveal the biases of the forecasts.

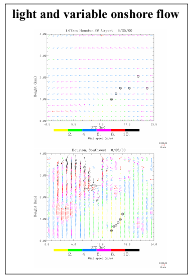
Process comparison using wind profiler and airborne ozone lidar measurements: to examine how well the model's forecasts compare with observations with respect to the primary meteorological process involved in the high surface ozone episodes: the sea-breeze and its interaction with the ambient gradient winds.

Sensitivity test: to use aircraft data to examine the sensitivity of wind forecasts to uncertainties in the initialization.

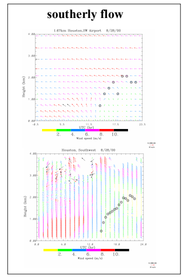
Numerical Model: The coupled weather-chemistry forecasting model combines a modified version of the fifth-generation Penn State/NCAR Mesoscale Model (MM5) and the chemical mechanism of the Regional Acid Deposition Model Version 2 (details about the coupled model can be found in Grell *et al.* 2000). The transport of chemical species (grid-scale and sub-grid scale) is treated simultaneously with meteorology. Photolysis, biogenic emissions, and deposition are also calculated "online". The model was run on multiple 1-way nested meshes 60 km, 15 km, 5 km, and 1.67 km resolutions for the TEXAS AQS study. The coarsest meshes were initialized using the Forecast Systems Laboratory/Rapid Update Cycle (FSL/RUC) analyses. The boundary conditions are provided by NCEP's ETA model forecasts. The chemical fields are initialized with the previous forecast to take into account the effect of accumulation. The emission input was compiled by using current federal and state emission inventory databases.

Model Forecasts and Wind Profiler Data Comparison

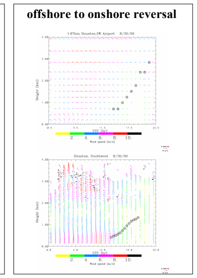
light and variable onshore flow



southerly flow

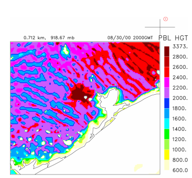


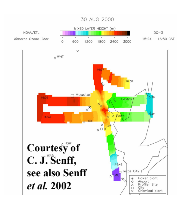
offshore to onshore reversal



Wind flow on each of the six days can be categorized into three different regimes with respect to prevailing surface winds: (i) light and variable onshore flow (25, 26 August), (ii) southerly flow (27, 28 August), and (iii) offshore to onshore reversal (29, 30 August).

Model Forecasts and Ozone Lidar Measurements Comparison





It has been known for a long time that the atmospheric boundary layer (ABL) height varies greatly in space across the sea-breeze front (see, e.g., Hsu 1979). The diagnosis of the model forecasts indicates that high surface ozone episodes in Houston are closely related to the day-time evolution of the southeast to northwest gradient of the ABL height. Such relevance is confirmed by the airborne lidar observations.

The following conclusions can be drawn from this study:

(1) The overall forecasted meteorological processes are compared well with the observations although the forecasted fields have biases.

(2) The forecasted change of low-level wind regime is in reasonable good agreement with observations.

(3) The forecasted land-sea breeze cycle is in good agreement with the wind-profiler observations, but differences do exist in the wind direction and speed.

(4) The forecasted PBL height has a northwest-southeast gradient across the sea-breeze front that is confirmed by the observations.

(5) The forecasted strength of the nocturnal low-level jet agrees fairly well with observations; however, the forecasted direction is more easterly than observed.

(6) The forecasted PBL mixing layer generally grows faster and deeper compared with observations, although the on-set of the PBL growth does compare well with observations.

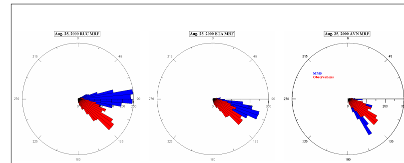
(7) The model forecasts possess a cold bias at low levels.

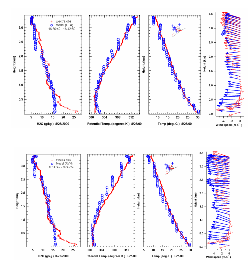
(8) The model forecasts are sensitive to different initial conditions.

(9) Although the grid resolution of the finest mesh is 1.67 km, the effective resolution of the model is about 10 km.

There are numerous uncertainties in both model forecasts and observations. Given the fact that one can only do so much to improve quantitative accuracy of the model physics and initialization, the air-quality forecasting community may want to explore the ensemble technique to reduce the uncertainties in quantitative air-quality forecasts.

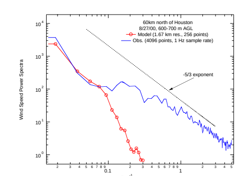
Sensitivity to Initial Conditions

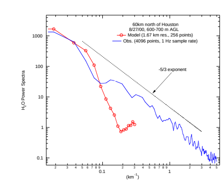




Comparison of the forecasted wind directions with aircraft measurement on 25 August 2000: to illustrate the sensitivity to different initial conditions. Blue indicates model; red indicates observations.

Comparison of the Aircraft-Measured and Model-Forecasted Power Spectra





The model forecast starts to differ significantly when the spatial scale is smaller than 10 km. If we believe that the scales corresponding to these peaks are significant to the transport of the surface ozone precursors, obviously the model's grid resolution is not fine enough to provide adequate effective resolution.